61. An apparatus for noninvasively measuring magnetic susceptibility variations in the body tissue of a patient to determine a compositional state in the body, the apparatus comprising:

a detector assembly that includes:

at least one magnetic sensor and an applied field coil for generating a magnetic field, said applied field coil comprising at least two concentric circular spiral coils; and

means for processing signals from said at least one magnetic sensor of observed magnetic susceptibility variations in body tissue;

a non-conductive, non-magnetic, substantially rigid barrier;

a flexible membrane sealed to said barrier to form a container therewith, there being a deformable material within and occupying most of the volume within said container, said material having a magnetic susceptibility substantially equivalent to that of the body tissue, said container also being deformable to fill in substantially all gaps between said barrier and the patient's body; and

means for outputting data from said detector assembly corresponding to a compositional state in the body;

wherein the at least two concentric spiral coils have diameters and numbers of turns chosen so that the magnetic field due to an inner concentric spiral coil cancels the magnetic field due to an outer concentric spiral coil in a region near the common center of the least two concentric coils, thereby producing a zone of substantially zero magnetic field, and wherein the at least one magnetic sensor is placed in said zone of substantially zero magnetic field.

62. The apparatus recited in claim 61, wherein the apparatus further comprises displacement means for displacing the at least one magnetic sensor and the applied field coil simultaneously, thereby compensating for noise introduced to the sensed signals.

63. The apparatus recited in claim 62, wherein the displacement means operates between about one to about six inches.

64. The apparatus recited in claim 62, wherein the displacement means operates at between about 0.5 to about 10.0 Hertz.

65. The apparatus recited in claim 61, wherein the instrument further comprises an electrostatic shield located between the sensor and the sample to be measured.

66. The apparatus recited in claim 65, wherein the electrostatic shield is octagonal in shape.

67. The apparatus recited in claim 65, wherein the electrostatic shield comprises conducting material arranged in the form of thin strips connected in a branching pattern.

68. The apparatus recited in claim 67, wherein the strips are about 0.01 inches in width.

69. The apparatus recited in claim 68, wherein there is a gap of about 0.01 inches between each strip.

70. An apparatus for noninvasively measuring magnetic susceptibility variations in the body tissue of a patient to determine a compositional state in the body, the apparatus comprising:

a detector assembly that includes:

at least one magnetic sensor and an applied field coil for generating a magnetic field;

an alternating current signal generating source which connects to said applied field coil;

means for processing signals from said at least one magnetic sensor of observed magnetic susceptibility variations in body tissues; and

an electrostatic shield positioned between said at least one magnetic sensor and the sample to be measured;

a non-conductive, non-magnetic, substantially rigid barrier;

a flexible membrane sealed to said barrier to form a container therewith, there being a deformable material within and occupying most of the volume within said container, said material having a magnetic susceptibility substantially equivalent to that of the body tissue, said container also being deformable to fill in substantially all gaps between said barrier and the patient's body; and

means for outputting data from said detector assembly corresponding to a compositional state in the body.

71. The apparatus recited in claim 70, wherein said sensor comprises a sensing coil, said sensing coil comprising a relatively tightly wound and compact spool of wire.

72. The apparatus of claim 70, wherein said applied field coil comprises at least two concentric circular spiral coils.

73. The apparatus of claim 70, wherein the electrostatic shield comprises sheets of conductive material wrapped to provide continuous shielding of electrical fields, wherein overlapping layers of the wrapped material are insulated to prevent electrical contact therebetween.

74. The apparatus of claim 70, wherein the electrostatic shield comprises thin strips of conductive material, electrically connected in a branching configuration so that all parts of the shield are electrically connected but such that there are no conducting loops enclosing large areas.

75. The apparatus of claim 74, wherein the strips are less than about 0.015 inches in width.

76. The apparatus of claim 75, wherein the conductive strips are arranged on a thin substrate.

77. The apparatus of claim 76, wherein the thin substrate comprises a printed circuit board.

78. The apparatus of claim 77, wherein the conductive strips are placed on opposite sides of the printed circuit board in a staggered relationship so that the strips on one side cover the area where there are gaps between the strips on the other side.

79. An apparatus for noninvasively measuring magnetic susceptibility variations in the body tissue of a patient to determine a compositional state in the body, the apparatus comprising:

a detector assembly that includes:

at least one magnetic sensor and an applied field coil for generating a magnetic field;

a current signal generating source, which connects to said applied field coil; and

means for processing signals from said at least one magnetic sensor of observed magnetic susceptibility variations in body tissue;

a non-conductive, non-magnetic, substantially rigid barrier;

a flexible membrane sealed to said barrier to form a container therewith, there being a deformable material within and occupying most of the volume within said container, said

material having a magnetic susceptibility substantially equivalent to that of the body tissue, said container being shaped and configured to fill in substantially all gaps between said barrier and the patient's body; and

means for outputting data from said detector assembly corresponding to a compositional state in the body;

wherein the at least one magnetic sensor comprises a sensing coil and wherein the applied field coil and the sensing coil are mounted together in a rigid sensor unit, and wherein the instrument is provided with displacement means for displacing the at least one magnetic sensor and the applied field coil simultaneously, thereby compensating for noise introduced to the sensed signals.

80. The apparatus of claim 79, wherein the applied field coil comprises at least two concentric circular spiral coils wherein the at least two concentric spiral coils have diameters and numbers of turns chosen so that the magnetic field due to an inner concentric spiral coil cancels the magnetic field due to an outer concentric spiral coil in a region near the common center of the at least two concentric coils, thereby producing a region of nearly zero magnetic field and wherein the at least one magnetic sensor is positioned in said region of nearly zero magnetic field.

81. The apparatus of claim 79, wherein the sensing coil and applied field coil are enclosed in an electrostatic shield.

82. The apparatus of claim 81, wherein the electrostatic shield comprises sheets of conductive material wrapped to provide continuous shielding of electrical fields, wherein overlapping layers of the wrapped material are insulated to prevent electrical contact therebetween.

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83. The apparatus of claim 81, wherein the electrostatic shield comprises thin strips of conductive material, electrically connected in a branching configuration so that all parts of the shield are electrically connected but such that there are no conducting loops enclosing large areas.

84. The apparatus of claim 83, wherein the strips are less than about 0.015 inches in width.

85. The apparatus of claim 84, wherein the conductive strips are arranged on a thin substrate.

86. The apparatus of claim 85, wherein the thin substrate comprises a printed circuit board.

87. The apparatus of claim 86, wherein the conductive strips are placed on opposite sides of the printed circuit board in a staggered relationship so that the strips on one side cover the area where there are gaps between the strips on the other side.

88. An apparatus for noninvasively measuring magnetic susceptibility variations in the body tissue of a patient to determine a compositional state in the body, the apparatus comprising:

a detector assembly that includes:

at least one magnetic sensor and an applied field coil for generating a magnetic field;

a current signal generating source, which connects to said applied field coil; and

means for processing signals from said at least one magnetic sensor of observed magnetic susceptibility variations in body tissue;

a non-conductive, non-magnetic, substantially rigid barrier;

a flexible membrane sealed to said barrier to form a container therewith, there being a deformable material within and occupying most of the volume within said container, said material having a magnetic susceptibility substantially equivalent to that of the body tissue, said container being shaped and configured to fill in substantially all gaps between said barrier and the patient's body; and

means for outputting data from said detector assembly corresponding to a compositional state in the body;

wherein the at least one magnetic sensor comprises a sensor unit, said sensor unit comprising two sensing coils connected in series, equal in area, but oppositely wound, and oppositely spaced from the applied field coil on a cylindrical coilform in a first-order gradiometer configuration;

wherein the sensing coils and applied field coil have areas and geometric locations chosen so as to cancel out the detected signal due to the applied magnetic field;

wherein the applied field coil and the sensing coils are mounted together in said sensor unit, and wherein the instrument is provided with means for displacing the sensor unit, thereby compensating for the effects of temperature drift; and

wherein the instrument further comprises an electrostatic shield between the sensing coils and the body tissue to be measured.

89. The apparatus of claim 88, wherein the means for displacing the sensing unit displaces the sensor unit toward and away from the body tissue.

90. The apparatus of claim 88, wherein the means for displacing the sensing unit displaces the sensor unit laterally with respect to the body tissue.

91. The apparatus of claim 88, wherein the applied field coil comprises a circular loop, and the sensing coils comprise a first order gradiometer, said gradiometer consisting of two oppositely wound coils of equal area, connected in series and located symmetrically with respect to the applied field coil so as to cancel out the detected signal due to the applied field.

92. The apparatus of claim 91, wherein the sensing coils are unequal in area, and their locations with respect to the applied field coil are chosen so as to cancel out the detected signal due to the applied field.

93. The apparatus of claim 88, wherein the applied field coil is a first order or higher gradiometer, and the sensing coils are configured as second order or higher gradiometers.

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94. A method for noninvasive determination of magnetic susceptibility variation in a patient by measuring magnetic susceptibilities of selected body tissue of the patient, the method comprising:

providing an instrument which includes at least one magnetic sensor and an applied field coil;

positioning on the patient a flexible bag substantially filled with deformable material having a magnetic susceptibility substantially similar to that of the body tissue, said bag being attached to a substantially rigid barrier, the barrier being spaced from the patient by the deformable material filled bag;

positioning the instrument external to the patient in proximity to the tissue of interest and adjacent the barrier;

supplying the applied field coil with current thereby applying a magnetic field to the tissue of interest;

scanning the at least one magnetic sensor along the rigid barrier to generate a map of susceptibility variations of the underlying body tissues; and

outputting data corresponding to the magnetic susceptibility variation in the tissue.

95. A method for noninvasive determination of magnetic susceptibility variation in a patient by measuring magnetic susceptibilities of selected body tissue of the patient, the method comprising:

providing an instrument which includes at least one magnetic sensor and an applied field coil;

positioning on the patient a flexible bag substantially filled with deformable material having a magnetic susceptibility substantially similar to that of the body tissue, said bag being attached to a substantially rigid barrier, the barrier being spaced from the patient by the deformable material filled bag;

positioning the instrument external to the patient in proximity to the tissue of interest and adjacent the barrier;

providing the instrument with displacement means for a displacement of the magnetic sensor and the applied field coil simultaneously, thereby compensating for noise that may be introduced to the sensed signals;

supplying the applied field coil with current thereby applying a magnetic field to the tissue of interest;

sensing a response from the tissue of interest with the instrument;

outputting data corresponding to the magnetic susceptibility variation in the tissue;

providing the instrument with means for withdrawing the magnetic field coil and applied field coil simultaneously from the patient;

repeating the sensing step and outputting step; and

subtracting the susceptibility measurement observed after the withdrawing step from the susceptibility measurement observed before the withdrawing step.

96. The method according to claim 95, wherein said displacement is between about one to about six inches.

97. The method according to claim 95, wherein the displacement means operates between about 0.5 to about 10.0 Hertz.

98. The method according to claim 95, wherein said withdrawal permits the drift in the sensor output to be subtracted out more effectively.

99. The method according to claim 95, wherein said displacement and withdrawal occur simultaneously.

100. An apparatus for noninvasively measuring magnetic susceptibility variations in the body tissue of a patient to determine a compositional state in the body, the apparatus comprising:

a detector assembly that includes:

at least one magnetic sensor and an applied field coil for generating a magnetic field;

a signal refinement means adjustably positioned with respect to the sensor;

a current signal generating source which connects to said applied field coil; and

means for processing signals from said at least one magnetic sensor of observed magnetic susceptibility variations in body tissue;

a non-conductive, non-magnetic, substantially rigid barrier;

a flexible membrane sealed to said barrier to form a container therewith, there being a deformable material within and occupying most of the volume within said container, said material having a magnetic susceptibility substantially equivalent to that of the body tissue, said container being shaped and configured to fill in substantially all gaps between said barrier and the patient's body; and

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means for outputting data from said detector assembly corresponding to a compositional state in the body;

wherein said applied field coil is designed to produce a region of nearly zero magnetic field and said sensor is positioned in said region of nearly zero magnetic field and wherein adjustment of said signal refinement means improves cancellation of the applied field at the sensor location.

101. The method of claim 100, wherein said signal refinement means is selected from the group consisting of a balance coil, ferromagnetic tabs on the coilform and an electronic imbalance sensing and compensating means.

102. The method of claim 101, wherein said balance coil is connected in series with the applied field coil.

103. The method of claim 101, wherein said balance coil is adjustable on an axis parallel to a longitudinal axis of the sensor.

104. The method of claim 101, wherein the balance coil comprises a plurality of turns of wire on a non-metallic, non-magnetic cylindrical coilform.

105. The method of claim 104, wherein the plurality of turns of wire is about 10 to about 20 and the cylindrical coilform diameter is about 1 to about 1.5 inches.

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106. An apparatus for noninvasively measuring magnetic susceptibility variations in the body tissue of a patient to determine a compositional state in the body, the apparatus comprising:

a detector assembly that includes:

at least one magnetic sensor and an applied field coil for generating a magnetic field;

an alternating current signal generating source, which connects to said applied field coil;

means for processing signals from said at least one magnetic sensor of observed magnetic susceptibility variations in body tissues; and

an electrostatic shield positioned between said at least one magnetic sensor and the sample to be measured; and

means for outputting data from said detector assembly corresponding to a compositional state in the body.

107. The apparatus recited in claim 106, wherein said sensor comprises a sensing coil, said sensing coil comprising a relatively tightly wound and compact spool of wire.

108. The apparatus of claim 106, wherein said applied field coil comprises at least two concentric circular spiral coils.

109. The apparatus of claim 106, wherein the electrostatic shield comprises sheets of conductive material wrapped to provide continuous shielding of electrical fields, wherein overlapping layers of the wrapped material are insulated to prevent electrical contact therebetween.

alt. cont.

110. The apparatus of claim 106, wherein the electrostatic shield comprises thin strips of conductive material, electrically connected in a branching configuration so that all parts of the shield are electrically connected but such that there are no conducting loops enclosing large areas.

111. The apparatus of claim 110, wherein the strips are less than about 0.015 inches in width.

112. The apparatus of claim 111, wherein the conductive strips are arranged on a thin substrate.

113. The apparatus of claim 112, wherein the thin substrate comprises a printed circuit board.

114. The apparatus of claim 113, wherein the conductive strips are placed on opposite sides of the printed circuit board in a staggered relationship so that the strips on one side cover the area where there are gaps between the strips on the other side.

115. An apparatus for noninvasively measuring magnetic susceptibility variations in the body tissue of a patient to determine a compositional state in the body, the apparatus comprising:

a detector assembly that includes:

at least one magnetic sensor and an applied field coil for generating a magnetic field;

a current signal generating source, which connects to said applied field coil; and

means for processing signals from said at least one magnetic sensor of observed magnetic susceptibility variations in the body tissue; and

means for outputting data from said detector assembly corresponding to a compositional state in the body;

wherein the at least one magnetic sensor comprises a sensor unit, said sensor unit comprising two sensing coils connected in series, equal in area, but oppositely wound, and oppositely spaced from the applied field coil on a cylindrical coilform in a first-order gradiometer configuration;

wherein the sensing coils and applied field coil have areas and geometric locations chosen so as to cancel out the detected signal due to the applied magnetic field;

wherein the applied field coil and the sensing coils are mounted together in said sensor unit, and wherein the instrument is provided with means for displacing the sensor unit, thereby compensating for the effects of temperature drift; and

wherein the instrument further comprises an electrostatic shield between the sensing coils and the body tissue to be measured.

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116. The apparatus of claim 115, wherein the means for displacing the sensing unit displaces the sensor unit toward and away from the body tissue.

117. The apparatus of claim 115, wherein the means for displacing the sensing unit displaces the sensor unit laterally with respect to the body tissue.

118. The apparatus of claim 115, wherein the applied field coil comprises a circular loop, and the sensing coils comprise a first order gradiometer, said gradiometer consisting of two oppositely wound coils of equal area, connected in series and located symmetrically with respect to the applied field coil so as to cancel out the detected signal due to the applied field.--